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(54) Process and Device for Producing Multilayered, Fiber-Reinforced Plaster Plates

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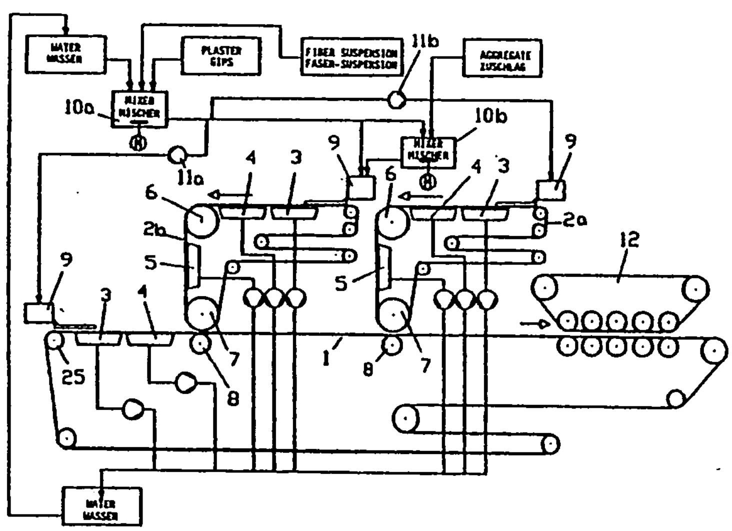
(54) Title: PROCESS AND DEVICE FOR PRODUCING MULTI-LAYERED, FIBRE-REINFORCED PLASTER PLATES

(54) Bezeichnung: VERFAHREN UND VORRICHTUNG ZUR HERSTELLUNG VON MEHRSCHICHTIGEN FASERVERSTÄRKTEN GIPSPLATTEN

(57) Abstract

Fibre-reinforced plaster plates are produced in a multi-layered continuous filtration process. A suspension of plaster and wet processed fibres, preferably from used paper, is dewatered on at least two travelling screens. At least two layers are produced in essentially identical filtering units that work in opposite directions. The layers are then reversed so that their top surfaces face each other. When three layers are processed, the central layer may be composed of a dispersible, binder-containing material. Several devices and process configurations are disclosed.



(57) Zusammenfassung

Gipsfaserplatten werden in einem mehrschichtigen kontinuierlichen Filtrationsverfahren hergestellt, indem eine Suspension von Gips und naß aufbereiteten Fasern, bevorzugt aus Altpapier, auf wenigstens zwei Siebbändern entwässert werden. Wenigsten zwei der Schichten werden aus im wesentlichen gleichen Filtriereinheiten erzeugt, die gegenläufig arbeiten. Die Schichten werden dann Oberseite auf Oberseite zusammengegautscht. Bei dreischichtiger Arbeitsweise kann die mittlere Schicht mit streubarem bindemittelhaltigem Material gebildet werden. Mehrere Vorrichtungen und Verfahrenskonfigurationen sind beschrieben.

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Patent Claims

1. Process for the continuous production of gypsum-fiber plates

- from gypsum hemihydrate and lignocellulose-containing reinforcement fibers
- with a content of reinforcement fibers of at least 3 % of the total dry mass
- according to a filtration process, whereby
- a thin flowable sludge (suspension) of hemihydrate and reinforcement fibers and optionally additives and admixed substances is distributed over a water-permeable transport belt (screen),
- excess water is removed basically though underpressure,
- the gypsum-fiber layer forms a filter cake,
- which is optionally further dewatered by mechanical pressing action, and which
- is left to settle and finally is thermally dried,

characterized in that

- the water content of the suspension is adjusted to the content of reinforcement fibers so that the suspension contains a maximum of approximately 3 % reinforcement fibers in relation to the water amount,

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- the dewatering through underpessure takes place in at least two separate webs in basically identical installations,

- in the further course of the process, prior to the setting of the gypsum, the dewatered gypsum-fiber layers are brought together and bonded, whereby
- the devices for the dewatering of at least two webs work in opposite directions and the gypsum-fiber layers of these webs are laid on top of each other in a mirror-image fashion.

2. Process according to claim 1, characterized in that the dewatering of the gypsum-fiber suspension takes place in three webs.

3. Process according to claim 2, characterized in that the composition of the suspension for the middle web is different from the one of the two outer webs.

4. Process according to claim 2, characterized in that the dewatering of the layer takes place in at least two stages with different underpressures.

5. Process according to claim 4, characterized in that the dewatering takes place in three stages with different underpressures, whereby the underpressure of the first zone is 15 to 65 mbar, in the second 65 to 200 mbar and in the third zone 200 to 550 mbar.

6. Process according to claim 4, characterized in that at least on one of the layers a basically dry layer of binders, optionally fibers, additives and admixed substances is dispersed.

7. Process according to claim 6, characterized in that the dispersion takes place on the at least partially dewatered layer.

8. Process according to claim 7, characterized in that the dewatering is performed with controlled pressure, so that a residual wetness of the dewatered layer of 50 to 80 % in relation to the dry mass is established, before the dry layer is dispersed.

9. Process according to claim 8, characterized in that the dry layer is predensified by mechanical pressure before being bonded with another dewatered layer.

10. Process according to claim 9, characterized in that the preliminary densification takes place above the last dewatering zone.

11. Process according to claim 4, characterized in that on the screens of the two webs forming the cover layers a water-permeable textile band is applied prior to spreading the suspension, which bonds with the forming plate.

12. Process according to claim 4, characterized in that on the lowermost web a layer of plaster mixed to a plastic paste is applied.

13. Process according to claim 12, characterized in that the plaster is a binder mixed into a paste together with prefabricated foam, optionally with additives and admixed substances

14. Process according to claim 4, characterized in that the thickness of the dewatered layers has 3 mm to 20 mm, preferably 4 mm to 10 mm.

15. Process according to claim 6, characterized in that a fraction of the dewatered fiber material, optionally dewatered to a consistency of 15 to 30 %, is ground in a mill and is admixed as a fiber material for the dispersion layer.

16. Process according to claim 15, characterized in that to a fraction of the dewatered fiber material waste paper is added, in an amount resulting in a total wetness content of 20 % to 50 % in relation to the dry content, then ground in a mill and admixed as a fiber material for the dispersion layer.

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17. Installation for implementing a process according to one of claims 1 to 16,

with at least one arrangement for producing and dewatering the gypsum-fiber suspension with

- a continuous dosage device for gypsum,
- a continuous dosage device for water,
- a continuous mixing device for fiber suspension, water and gypsum and optionally admixed substances and additives
- a distribution device for the gypsum-fiber suspension,
- a dewatering screen belt with at least two dewatering suction devices arranged underneath the screen, which are operated with underpressure and

with a continuous press,

characterized by

- at least two basically identical arrangements for producing and dewatering the gypsum-fiber suspension,
- whose dewatering screen belts are brought together downstream of the dewatering suction devices,
- whereby two of the dewatering screen belts work in opposite directions and

- and at least one dewatering screen belt is guided over rollers with a large diameter, after passing the dewatering suction devices and before the webs are brought together.

18. Installation according to claim 17, characterized in that it comprises a main dewatering screen, over which at least one further secondary screen running in opposite direction is arranged (Figure 2).

19. Installation according to claim 18, characterized in that it comprises two oppositely running dewatering screens arranged in a single plane, butting against each other and the two dewatered gypsum-fiber layers couch together over a large diameter drum (Figure 3).

20. Installation according to claim 18, characterized in that above the main dewatering screen a dispersion machine for the dispersable mixture is arranged, which disperses onto the dewatered gypsum-fiber layer.

21. Installation according to claim 20, characterized in that above the main dewatering screen downstream of the dispersion machine a densification press with screen stress is arranged, which predensifies and vents the dispersed material prior to its bonding with the second dewatered gypsum-fiber layer (Figure 4).

22. Installation according to one of claims 18 to 21, characterized in that after the separate layers are brought together a press is provided.

23. Installation according to claim 22, characterized in that the press is an isostatic press.

24. Installation according to claim 23, characterized in that the press operates basically due to its own weight.

25. Installation according to claim 22, that the press is clearance-controlled.

26. Installation according to claim 22, characterized in that the press has a lower screen belt and an upper solid press belt.

27. Installation according to claim 26, characterized in that the press has a lower screen belt and an upper solid press belt with a structured surface.

28. Installation consisting of any desired combination of the basic variants according to claims 39 to 50.

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PROCESS AND DEVICE FOR PRODUCING MULTILAYERED FIBER-REINFORCED PLASTER PLATES

- The wet paper treatment is a perfectly controlled technology, which does not apply to the dry treatment.

- The wet paper treatment consumes much less electric energy than the dry one. This more than compensates for the drawback of higher thermal energy consumption during the drying of the plate.

- Wet processes do not require heavy-duty presses, which count for a large part of the investment costs in dry processes. The specific investment costs for wet processes are therefore lower in installations with low output.

In the wet processes often the long-known Hatschek process, respectively related processes, such as known in the technology of asbestos cement plates, are used. A first patent of this kind

is the DE 1 104 419. Thereby a suspension of gypsum and fibers is deposited on a screen or textile felt and then transferred as a fleece to a roller with a large diameter, where it is wound up until the desired plate thickness is reached. Then the layer is separated along the generatrix of the cylinder and the wound-off portion forms a raw plate, which settles between sheet metal plates and is finally dried.

In 1973 Knauf resumed the development (DE 23 62 220). It became possible to multiply the output of a Hatschek machine, by using aridized gypsum.

Another process is the so-called endless screen-belt process, which is derived from paper manufacturing. An example is described in OS 23 65 161 of the Portland-Zementwerke Heidelberg. Thereby a suspension of gypsum and scrap fibers from the cellulose manufacturing are formed in a single layer into a plate, left to settle and dried.

Babcock tries to avoid the problems arising from the processing of wet, settable gypsum by first producing a raw plate of a paper-fiber suspension and finely milled raw gypsum on an endless screen-belt forming machine. After that the plate is treated in an autoclave, whereby the dihydrate is converted into settable alpha-hemihydrate. Subsequently the plate is cooled, left to settle again in its own wetness and dried (DE 34 19 558.).

In Japan numerous wet processes for GF-plates have been developed. NIPPON HARDBOARD (OS 28 33 550), ONODA-ASANO (OS 2 417 558) and NIHON CEMENT (US 3 951 735) have to be mentioned. The Japanese processes favor alpha-gypsum as binder, in order to obtain thin plates with high strength. These are all modified Hatschek or endless screen-belt processes.

As already mentioned above by far the biggest problem is the mechanical dewatering of a gypsum-fiber suspension. The Hatschek process uses the fact that the filtering speed decreases with the square of the filter cake thickness, but the mass throughput decreases only linearly with reference to the thickness. Therefore a number of thin dewatered layers are wound on top of each other on a drum, in order to obtain the desired plate thickness. After that the "coil" is sectioned along a generatrix and spread out. It is clear that the production output of such an installation is limited, since the centrifugal forces and the sluggishness of the mass limit the peripheral speed of the drum when the plate is laid out.

In the endless screen-belt process the dewatering time increases and thereby the surfaces subjected to underpressure, increase by a square of the thickness, so that above a certain screen speed, the necessary propulsive output can no longer be transmitted to the screen.

In the endless screen-belt process above a certain thickness of the filter cake, the pressure decrease in the cake can become bigger than the applied suction, so that the uppermost layer of the filter cake

is not dewatered. This happens primarily with the customary plaster of Paris, which when in contact with water tends to decompose into very fine particles, thereby building up an enormous filter resistance. Thereby the maximal thickness of a filter layer is limited.

A few basic principles which have to be observed in the endless screen-belt process are described below:

The selection of the gypsum is very important for the success of the process. In order to insure that a suspension will be well filtered, the particle size distribution and the shape of the suspended solid matter have to meet certain conditions. The following requirements apply to the gypsum:

a) a bulk density higher than 950 g/l in the case of alpha-hemihydrate, respectively higher than 700 g/l in the case of beta-hemihydrate.

b) a particle size distribution which corresponds to an angle of inclination RRSB grain grid of more than 40°.

c) in the case of beta-hemihydrate it has to be aridized and can not be milled again after calcination.

Advantageously to the burnt gypsum hydraulically setting binders can also be added. This is not self-understood, since for instance in the semi-dry process the water amount in the raw plate is mostly not

sufficient for the correct setting of the hydraulic binder. This danger does not exist in the filtration process. So with particularly good results it is possible to admix high alumina cement, and blast furnace cement (HOZ), respectively ground blast furnace slag and Portland cement. The raw plates have then to undergo a longer maturing period. This way plates are obtained which have an improved water resistance.

The addition of 10 to 30 % of high alumina cement and 30 % to 50 % HOZ has proven to be particularly advantageous. The addition of such hydraulic substances can improve the filtration characteristics of needle-shaped gypsums to an extent that they can be used.

A good filtering ability of the gypsum-fiber suspension allows for the dewatering of relatively thick layers. Thereby the fiber distributed throughout the suspension and the gypsum itself act as a filter. Therefore in this case it is also not necessary to insert a felt with high filtering resistance as a filtering belt, a screen is sufficient. The required filtering surface, the underpressure and the suction time depend on the combined filtering resistance. In the end this is what determines the throughput of an installation, as well as the required propulsion output for filter belt and vacuum pumps.

The thickness of the dewatered layer should not fall below a minimum of 3 mm, because otherwise the losses of solid matter aspired with the water increase dramatically .

It has been found that a content of cellulose fibers, respectively an equivalent of waste paper, of at least 3 % of the total mass should be used in order to reduce suction losses, but also to prevent a demixing of the suspension. The preferred range when working with cellulose fibers alone lies between 7 % and 12 %. At this fiber content the density of the finished GF-plate establishes itself between approximately 1.1 and 0.6 T/m^3, respectively. At the same time the strength reaches a maximum within this range. This applies to the case when the dewatered layer is not subsequently densified by a press.

The dewatering of the layer takes place in at least two zones with different underpressure. The more subdivisions are made, the more the suction distribution can be improved with regard to various criteria. The distribution for the lowest possible energy use by the pumps is different from the one for the shortest possible dewatering zone or for the smallest possible screen tension. However in practice the range of natural variations of the raw-material properties is so broad, that a subdivision into more than three zones does not seem to make sense. It applies generally that the dewatering should start with low underpressure, i.e. up to 65 mbar, should be continued with medium underpressure, i.e. up to 150 mbar and be concluded with high underpressure, i.e. up to 550 mbar. When only two dewatering zones operate, then the intermediate stage is eliminated.

The dewatering should be done in the first zone until the surface of the layer becomes mat. Therefore at a given length of the dewatering

zone, optionally the screen speed and/or the underpressure have to be adjusted to this measure.

The residual wetness and therewith finally the density of the finished plate is determined by various parameters, from which some are set by the properties of the used materials. If these are regarded as constant, then the most important influencing values are the thickness of the dewatered layer, the consistency of the suspension and the content of cellulosic fibers in the suspension. The thickness of the layer, as well as the consistency determine primarily the suction time, i.e. the maximal speed of the screen. The limit wetness is on the contrary determined primarily by the content of cellulose fibers. The maximum of applied suction as well as the suction time are here of secondary importance.

If one wants to eliminate this dependence, there remains as a way out the subsequent compression by squeezing out water. This does not contradict the possibilities of the process of the invention, however it is not desirable because the required presses are expensive and complicated.

Plaster of Paris is three or four times more soluble in water than dihydrate. With the large amounts of water which are used in the process, this fact can create a few problems. When for instance the water obtained from the dewatering of the gypsum-fiber suspension is returned to the

paper treatment, then up to 2 % of the plaster of Paris used in the paper suspension as a dihydride can be lost. This is not only a loss of binder, but can also destabilize the process, because dihydride has a strong accelerating action on the setting of the gypsum. It is therefore an essential feature of the invention to keep the water cycles of the paper preparation and of the plate formation separated as much as possible.

The water cycle in the plate-forming system results from the water which is removed from the gypsum-fiber suspension and returned to the mixture. During dewatering approximately 1 % to 3 % of the solid matter is entrained. In order to avoid that the gypsum deposits in intercalated buffer containers, it is removed in a sedimentation funnel and returned to the mixer over a short way. The separation of the solid matter is assisted by the addition of polymeric flocculation agents known per se.

The quality of the plate created through dewatering is determined to a large extent by the consistency of the gypsum-fiber suspension. This has to be set so that a free flow of the material is insured. When the consistency is too low, the dewatering times and the losses of binder increase. When the consistency is to high, the fibers can interlock. This hinders the orientation of the fiber in the plate plane and leads to net-like zones of lower fiber content and thereby weaken the general strength of the plate. Therefore it is necessary to select a water content of the suspension which is as low as possible, but still insures flowability.

The flowability is primarily a function of the fiber content. The binder content plays a secondary part. As a control value a content of approximately 3 % cellulose fiber with reference to the water amount can be assumed by the suspension, a value which should not be surpassed. In practice the optimal value can slightly deviate from this value.

As soon as the plate is formed, it is trimmed at the lateral edges. The border strips are mixed as soon as possible with the cycle water and again directed to the mixer. The proportion of the border strips in the mixer is quite considerable. Each passage through the cycle increases quite considerably the proportion of the finest particles, which hinder the filtration. Here too is a source of instability, like in the case of the nuclei accelerating the setting.

Unfortunately in this case there is no safe and efficient means of facing this, except for throwing away the border strips. This is not reasonable from an economic point of view. Therefore this proportion has to be kept as low as possible and the preparation has to be performed as gently as possible. A way to diminish the proportion is the selection of a large work width. Also special care has to be taken to keep the unavoidable border strip effect to a minimum in the transverse mass distribution.

Before the setting starts in, the continuous web of GF-plates has to be subdivided and separated, because the plate expands during setting up to 5mm/m. In a plate that has not yet been separated, this would lead to warping.

The separation into individual plates offers the possibility to select the way in which the plates would be temporarily stored prior to drying. In quickly setting gypsum a correspondingly narrow transport belt is suitable. When hydraulic binders are used, stacking between sheet metal plates or other plates is known.

The present invention describes a possibility to overcome the above-mentioned problems in the implementation of high production outputs by means of a wet process and to create an endless screen belt process for the production of gypsum fiber plates with a high output.
Its most important feature is that

the dewatering through underpressure takes place in at least two separate webs on basically identical devices which operate in opposite directions, and that at least two of the dewatered gypsum-fiber layers are brought together, superimposed in a mirror-image fashion and bonded in the further course of the process, prior to setting.

When one operates with three dewatering devices, the middle layer can have a different composition than the two outer layers, within the limits set by the method, e.g. the fiber content can be reduced or additional substances can be admixed.

A particularly advantageous embodiment of the process is that at least on one of the dewatered layers a basically dry mixture of binders,

additives and optionally fibers is dispersed. Then before the last layer is laid down, the mixture is pressed onto the first layer with a light press and predensified. (see Figure 3 and Example 4).

In this case dry basically means that the mixture can be dispersed. It can contain a proportion of up to approximately 25 % wetness with reference to the solid matter (compared to over 400 % in the GF-suspension). Only few fibers means that they do not loosen the mixture. In the case of cellulose fibers the upper limit can already lie at 1 %, in the case of certain mineral fibers the maximum possible proportion can lie at 10 %.

Since it is always difficult to moisten a dry mixture, advantageously the used lignocellulose-containing fiber is prepared wet and again dewatered mechanically. ~~This way a small quantity of water can be brought~~ in right away. In addition a part of the machinery required for the dry preparation becomes superfluous.

In an embodiment of the process of the invention, the dispersion process can take place right after the first dewatering stage. In this case it is advantageous to interrupt the dewatering though underpressure and to resume it where the densification by means of a press takes place. Thereby the venting of the dispersed layer is helped. If the mixture contains no or only few fibers, the preliminary densification can be eliminated.

The most important advantage of this kind of procedure is that the residual wetness in the cover layers is reduced to values which otherwise can be reached only by using dewatering presses, since the dry mass of the wet layer extracts water through capillary forces.

A further advantage is for instance that perlite can be introduced into the plate without saturating it with water, which requires a long time and a lot of thermal energy during drying. Also during this dry introduction a demixing can be extensively avoided. In a special embodiment of the process the perlite or another additive is granulated with the binder in an appropriate device with the addition of water. This way a particularly uniform distribution of binder and additives is achieved and the forming of dust during dispersion is avoided. (compare Example 5)

Extremely light plates or plates with a very reduced fiber content are not particularly strong and tend to flake in the case of light plates. In an embodiment of the process according to the invention, reinforcing, respectively protective fabrics or fleece are positioned on the screen belt, before the gypsum-fiber suspension is distributed there. When a reinforcing effect is desired, the textile web has to be traction-resistant and to possess a high elasticity module. A synthetically bound glass-fiber fleece has to be especially mentioned, which also has the advantage of being nonflammable.

During dewatering gypsum penetrates the textile and bonds it tightly with the layer. This is not possible when only one layer is dewatered.

Then namely a textile positioned on top of the dewatered layer does not bond with the layer. However a plate with only one textile layer will bend.

A special variant of the process consists in that the middle layer is neither dispersed nor filtered, but is cast. Thereby a pulp of binders stirred with water and optionally admixed substances and additives are poured onto a filter layer and covered by a second filter layer (see Figure 6). This development of the process reminds of the production method of gypsum-cardboard plates.

In this variant the binder can be prepared also with previously prepared aqueous foam. This way a mass results which can be easily distributed, but which still contains little water and will have a porous structure after setting. If it is intended to improve the bonding with the filter layers, an antifoaming agent can be added to he filtered suspension, which thickens the mass at the border layers. Such a procedure is particularly suitable for plates with a thick core and thin covering layers.

In an embodiment of the invention light admixed substances, such as perlite, can be used, which tend to collect in the upper layer of the dewatered gypsum-fiber layer. During the symmetrical joining of the plates, this way an enriched core of the plate is achieved, which has a particularly favorable effect on the mechanical properties of the plate.

Figure 1 shows the flow sheet of the process of the invention. The full lines correspond to the variant with two webs the broken lines describe the variant with dry material dispersed on one web. The circles with arrows K1 and K2 indicate the separate water cycles. Not indicated is a third water cycle which is not referred-to in the above description and which is coupled with the second one. It is the washwater cycle for the screens and belts participating in the dewatering.

Here a complication can occur when fresh water has to be introduced in the cycle. In the preliminary dewatering of the fiber material it is technically not possible to fall below the amount of water which is taken out with the plate. This way there is no latitude for the introduction of fresh water in the GF-cycle (K2). As a rule the water management is just balanced. The water amount introduced during washing from the GF-cycle (K2) has to be evacuated and treated to the extent that it can be returned to the wash cycle, respectively it can be fed with the fresh water in the paper cycle (K1).

Cleverly the total water amount of the GF-cycle (K2) runs then over the sedimentation, this way already removing the suspended solid matter. In the treatment of the residual water then only the dissolved gypsum has to be taken care of. The supersaturation of the water with dihydrate, which is approximately triple, is suitably reduced to 1.5 up to 2 times in a sufficiently large intermediate buffer tank wherein the dihydrate can precipitate. When after that it is also diluted with fresh water, dihydrate can no longer precipitate.

According to Figure 1 the dust from grinding is introduced in the calcinator and again transformed into settable material. In practice this can also create a problem, because the dust from grinding is very fine and can impair the filtering properties of the gypsum. The proportion of grinding dust which can be returned to the gypsum has to be tested in each case. In the case where a dry dispersion is used as a middle layer, an elegant solution to this problem is offered: since the calcination is anyway done in batches, a portion of the gypsum can be burnt together with the entire grinding dust. It is then used exclusively for the middle layer.

The process flow can be explained with the aid of a few examples. The process steps which need no further explanation, will thereby not be described in detail. In Table 1 the relevant parameters are listed.

- The gypsum is an aridized flue-gas gypsum, originating from a flue-gas scrubber of a power plant running on mineral coal, wherein limestone was the absorbent.

- The used fiber is waste paper subjected to wet treatment with a proportion of 15 % of sulfate paper.

- The necessary types and amounts of used additives which can be easily established by any person skilled in the art are not indicated.

- In a state pressed at 0.8 N/mm» the perlite has a weight by volume of 150 g/l.

- The amounts to be used refer to the unground plate. During grinding, approximately 0.5 mm are ground off.

- The Examples 1 to 3 can run with an installation according to the later described Figures 2 and 3.

- The examples 4 and 5 can be run on an installation according to Figure 4.

- The three absorption zones for each cover layers are each 2 m long.

- In all cases the subsequent densification with a press has been eliminated.

TABLE 1 Examples

		Exmpl 1	Exmpl 2	Exmpl 3	Exmpl 4	Exmpl 5
1 Setting values for covering layers (wet filtering)						
belt speed	m/min	14.7	9.8	7.8	31.6	31.6
corresponds to capacity	m»/h	2200	1500	1200	4700	4700
fiber material cons. before dilution	%	13	14	13.5	13.5	13.5
fiber material cons. after dilution	%	5.0	5.0	5.0	5.0	5.0
water in fiber after dilution	kg/min	406	345	308	601	601
fiber proportion in GF-raw mixture	%	8.0	12.0	10.0	10.0	10.0
gypsum proportion in GF-raw mixture	%	32.0	88.0	90.0	90.0	90.0
Consistency of Suspension	%	25.0	25.0	25.0	25.0	25.0
fiber amount in suspension	kg/min	21.4	18.2	16.2	31.6	31.6
gypsum in suspension	kg/min	246	133	146	285	285
water in suspension	kg/min	1069	606	649	1265	1265
water in cycle	kg/min	909	484	536	1044	1044
therefrom in fiber	kg/min	263	234	204	398	398
for border strips	kg/min	30	16	18	78	72
in mixer	kg/min	615	235	314	567	573

II Setting values for core layer (dry dispersion)

fiber proportion in GF-raw mixture	%	0	0	0	12.0	0.0
gypsum proportion in GF--raw mixture	%	0	0	0	88.0	100
wetness in GF-dry mixture	%	0	0	0	22	20
fiber mass in GF-dry mixture	kg/min	0	0	0	39.2	0.0
gypsum mass in GF-dry mix	kg/min	0	0	0	288	275
water mass in GF-dry mixture	kg/min	0	0	0	72	55
perlite mass in GF-dry mix	kg/min	0	0	0	7.0	14.0

Table II Continuation

III Plate characteristics

Total thickness	mm	10.5	10.5	12.9	12.0	11.0
therefrom cover layers	mm	10.5	10.5	12.9	6.4	6.4
therefrom core layer	mm	-.-	-.-	-.-	5.6	4.6
Total density	kg/m^3	820	690	760	790	805
therefrom cover layers	kg/m^3	820	690	760	760	760
therefrom core layer	kg/m^3	-.-	-.-	-.-	824	867
Fiber prop. in cover layers	%	7.0	10.6	8.8	8.8	8.8
Fiber prop. in core layer	%	-.-	-.-	-.-	10.6	0.0
water to dry (total)	%	40.0	58.34	49.2	27.6	26.7
bending resistance of plate	N/mm»	6.0	5.5	7.5	6.0	5.0

The Examples 1 to three vary the fiber content and the plate thickness. The maximum bending resistance is somewhere in the vicinity of 10 % fiber content. Also a strong dependence of the production output on fiber content and thickness can be found. The wetness to be dried lies in Examples 1 to 3 within a 50 % range with respect to the weight of the dry plate.

The values for capacity and wetness improve dramatically when a middle layer is dispersed. However the bending resistance decreases thereby noticeably. It can be seen that the densities of the plates are very low. They lie throughout within the range of GK-plates, GF-plates which were produced by the dry or semi-dry processes, and have densities of 1100 to 1200 kg/m^3, respectively 860 to 1000 kg/m^3, with perlite. Thereby the use of perlite and fiber per weight unit is clearly higher. With smaller amounts of perlite or fiber, and therefore also smaller amount of gypsum because of the lower density of the plates, the production costs decrease considerably compared to the dry/semi-dry processes.

The bending strength of the plates produced according to the process of the invention lies within the same range as that of the plates produced by the dry process. Therefore the ratio of strength to weight and thereby the handling of the plates produced by the wet process is better. A further advantage of technical applicability compared to the GF-plates from a dry or semi-dry process is that due to the reduced density, they offer less resistance to screws or nails. Particularly the penetration of screw heads which is accompanied by a compression of the material, is here much easier. But a disadvantage is that the surface hardness of plates

produced by the wet process is clearly lower than in the plates produced by the dry process with equal resistance.

An installation for implementing the process consist basically of:

a at least one continuous dosage device for gypsum

b at least one continuous dosage device for water,

c at least one continuous mixing device for fiber suspension, water and gypsum, optionally admixed substances and additives,

d at least two distribution devices for the gypsum-fiber suspension,

e at least two dewatering screen belts, each with at least two dewatering suction devices arranged underneath the screens and which work with different underpressures,

f optionally one or more devices for dispersing a dry layer,

g optionally one or more devices for preliminary densification of the dispersed layer,

h a continuous press.

In Figures 2 to 6 various embodiments of dewatering and molding installations are shown, which form the core of the installation according to the invention.

Figure 2 shows schematically the construction of one of the two basic variants of the plate-forming machine. Over a main dewatering screen (1) which as a leading screen predetermines the speed, one or more secondary screens (2a) and (2b) are arranged, whose dewatering output is equal to the one of the main screen. In the present case each screen has a suction zone with low underpressure (3) and one with high underpressure (4). The suction zones (5) at the secondary screens are underpressure suction devices which no longer have a dewatering effect, but only insure that the filter layer remains on the screen. The guide rolls (6) at the secondary screens, as well as the couch roll (7) have a large diameter in order not to pull the filter layer. Underneath the couch roll the corresponding counter-rollers (8) are provided. The devices for the transverse distribution of the suspension are identical for all screens. Various constructions are known which have proven themselves in the azbestos-cement technology.

The gypsum-fiber suspension is prepared in a single mixer (10a). This insures that the composition is the same at least in the cover layers. When the middle layer is supposed to have another composition, a second mixer (10b) is used. The distribution of the suspension over the individual screens is done by volumetric dosage pumps (11a, 11b), namely in the manner that the number of pumps is smaller by 1 than the number of molding machines.

The couched gypsum-fiber web is finally pressed with a press (12). As a rule the press is nothing else but a smoothing press, which with very light pressure, e.g. less than 0.5 N/mm», reduces the marks left by the screens. But it is also possible to build the press as a dewatering press, which is capable of densifying the gypsum-fiber web. The thereby required pressures are higher approximately by one size. When the press acts as a dewatering press, care has to be taken to remove the water. This can happen for instance when deeply grooved rubber belts with a high Shore hardness are used as press belts.

Figure 3 shows the second of the two basic variants for the implementation of the process of the invention. The essential difference over the first variant is that the screens (13a, 13b) lie in a single plane and butt each other frontally. Here too the guide rollers (6) have a large diameter. Particularly the roller (7b) is built big, in order not to tear the thicker plate.

The screen (13a) is guided together with the screen (13b) around the roller (14). This way a perfect synchronization of the belt speeds is reached. Furthermore the screen tension of screen (13a) exerts a pressing action which can have a dewatering effect, depending on the screen tension and the roller radius. For this reason in certain cases the press (12) can be eliminated.

Figure 4 shows the installation with a dispersed middle layer. It is a descendant of the basic variant shown in Figure 2. Here the main screen (1) which passes through in a straight line is the carrier of the dispersed layer which can not be bent over a roller without being damaged.

The dispersion machine (14) is of the kind which is used in the semi-dry processes and which again have been developed from the chipboard dispersion machines. The mixer (15) for the dry mix is a mixer adjusted to the conditions of gypsum mixing, such as used in the gluing of chips. Such a mixer is used in the semi-dry process. It also allows for the uniform distribution of small amounts of water in the mixture.

The preliminary press (16) densifies the dispersed mass to approximately 30 % of the dispersion height. For this only a very low pressure is needed. For this reason a row of rollers is sufficient. They are protected from direct contact with the dispersed layer by an endless belt (17). When as shown in Figure 4 the preliminary press starts to operate after the dewatering stretch, then the belt is cleverly a screen which allows for the venting of the mat. When the press starts to act after the last dewatering zone, then a solid belt can be used. This has the advantage that the continuous cleaning of the belt is less expensive. In addition to the preliminary densification, the preliminary press also has the task to smoothen the dispersed layer, so that the superposed cover layer can adhere smoothly

In the variant shown here the press (12) has therefore to be of a stronger design than in other variants, when the dispersed layer contains more than 5 % dry treated paper fibers. The fibers build up considerable restoring forces, which can be overcome only by relatively high pressures of the order of 1 Mpa.

The press itself can be built in various ways corresponding to requirements. Isostatic presses are suitable in most cases. For special requirements presses with clearance control can be used. It is also possible to use the press for determining the configuration of the plate surface, by using a smooth or structured press band.

Figure 5 shows the variant with additional cover layers of textile bands (18) which are applied on the screen (1) before the suspension is fed in. The webs run over drawing roller (19), which prevents the formation of folds and prestresses the web. Otherwise the installation is the same as in Figure 2, except that it works without the middle layer. However it is also possible to have a middle layer. With the additional external reinforcement, the core can then be very lightweight and without fibers. The textile webs can also be combined without further ado with the variant described in Figure 6.

In the variant described in Figure 6 the middle layer is cast. The mass to be cast (plaster) is mixed in mixer (20). This mixer can be a mixer for gypsum-cardboard plates or a special mixer for producing foamed plaster. The mass is spread onto the dewatered layer on the screen (1) by a distribution device.

The plaster is plastic and can be squeezed out laterally under the contact pressure of the upper screen. This is prevented by two lateral, concomitantly running belts (22) of very soft rubber, which have a rectangular cross section and are so thick that they are pressed in between the screens.

A preliminary press is not necessary in this case. It is replaced by several smoothing and shaping rollers (23) with counterpressing rollers (24) integrated in the dewatering machine (2), which can also be replaced by a simple plate (not shown in the drawing).

Of course there are also other possible combinations of the basic variant which are not described nor illustrated here, so for instance the 2nd basic variant (Figure 3) can be combined with one or two of the above filtering units as in Figure 1 (2a).

It has also to be mentioned that the method of reverse forming machines can be cleverly replaced also for other binders and basically different applications. The variant in Figure 3 can for instance be used as a filter press for dewatering any sludge.

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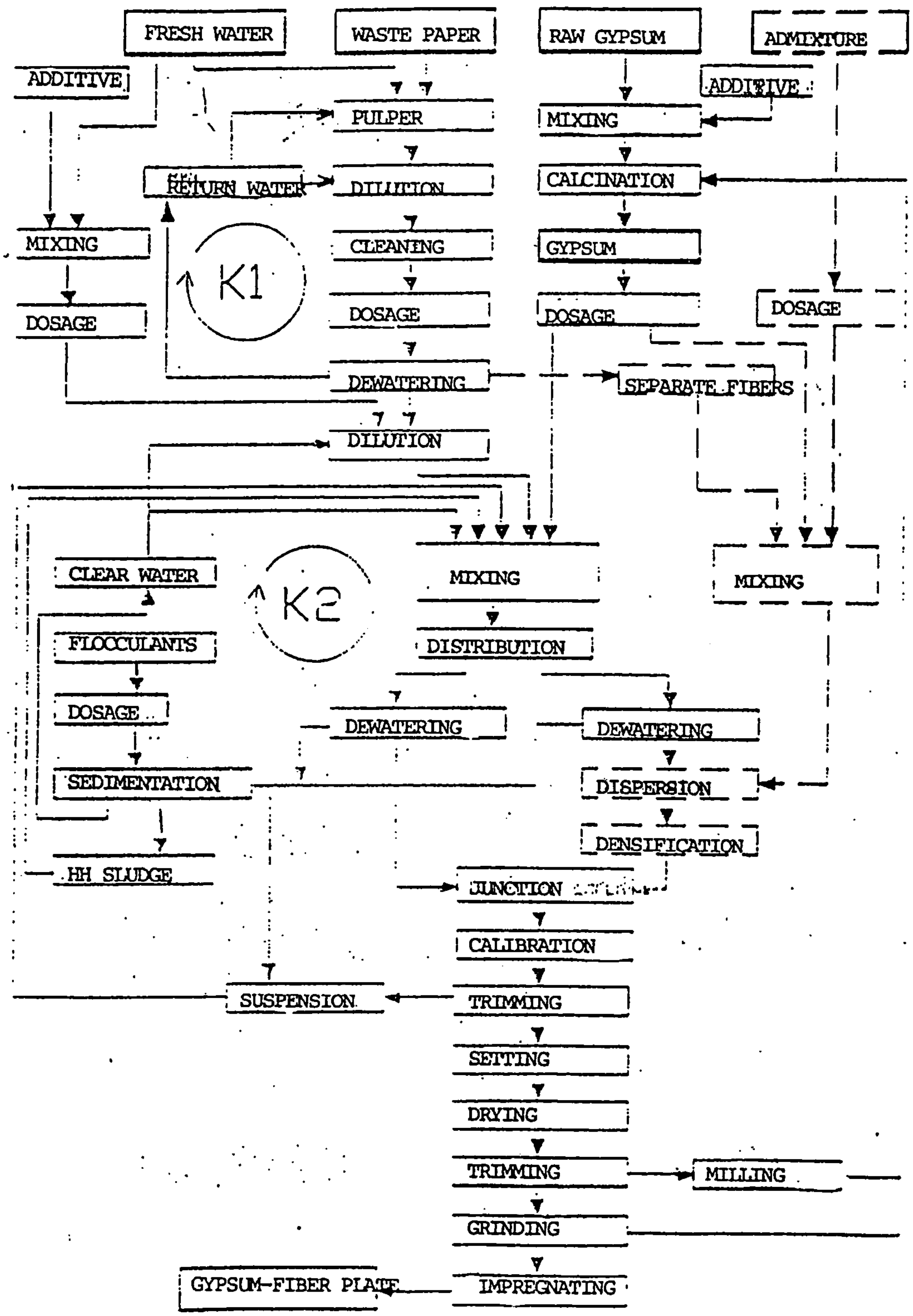
FIGURE 1



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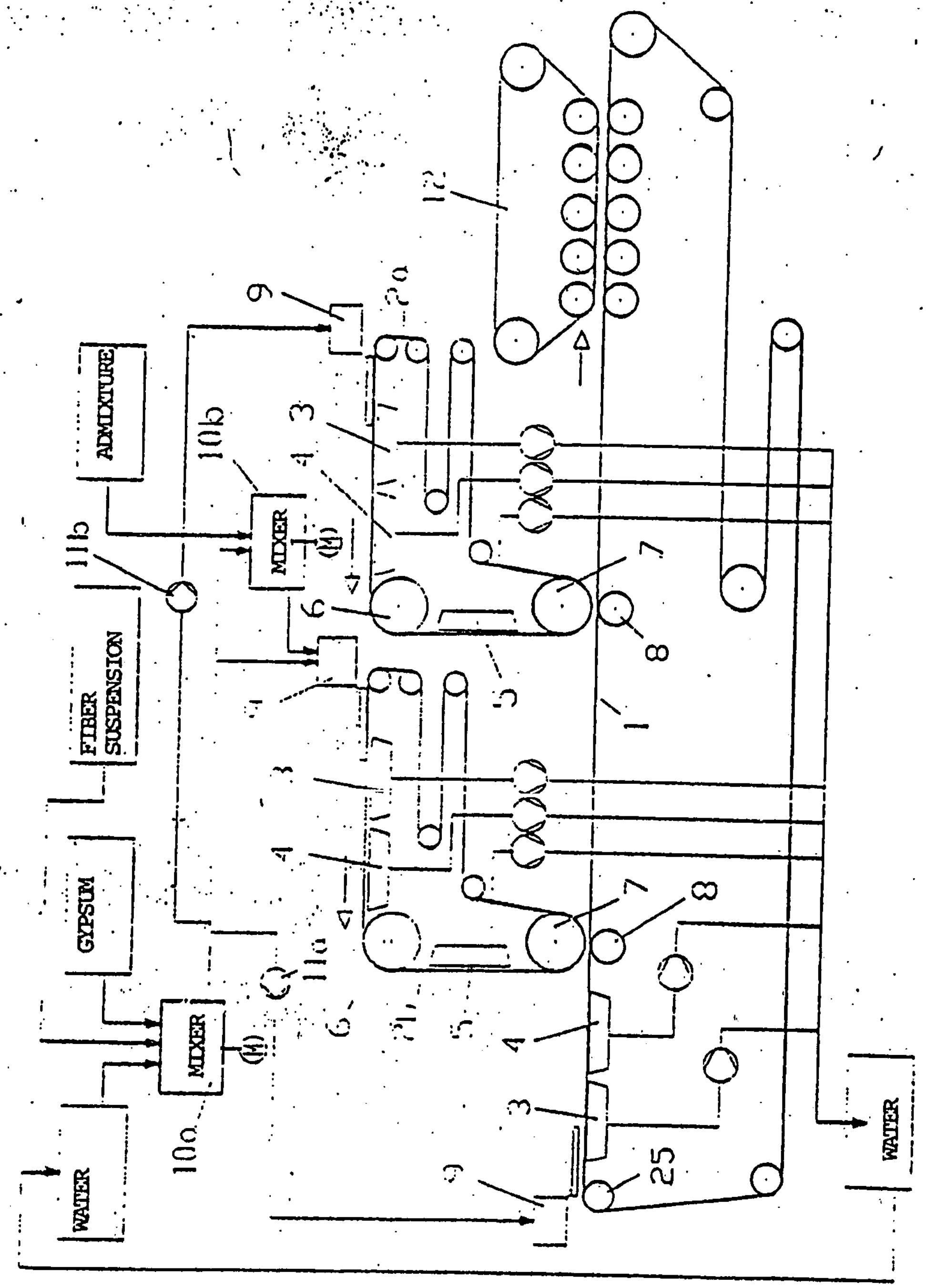

FIGURE 2

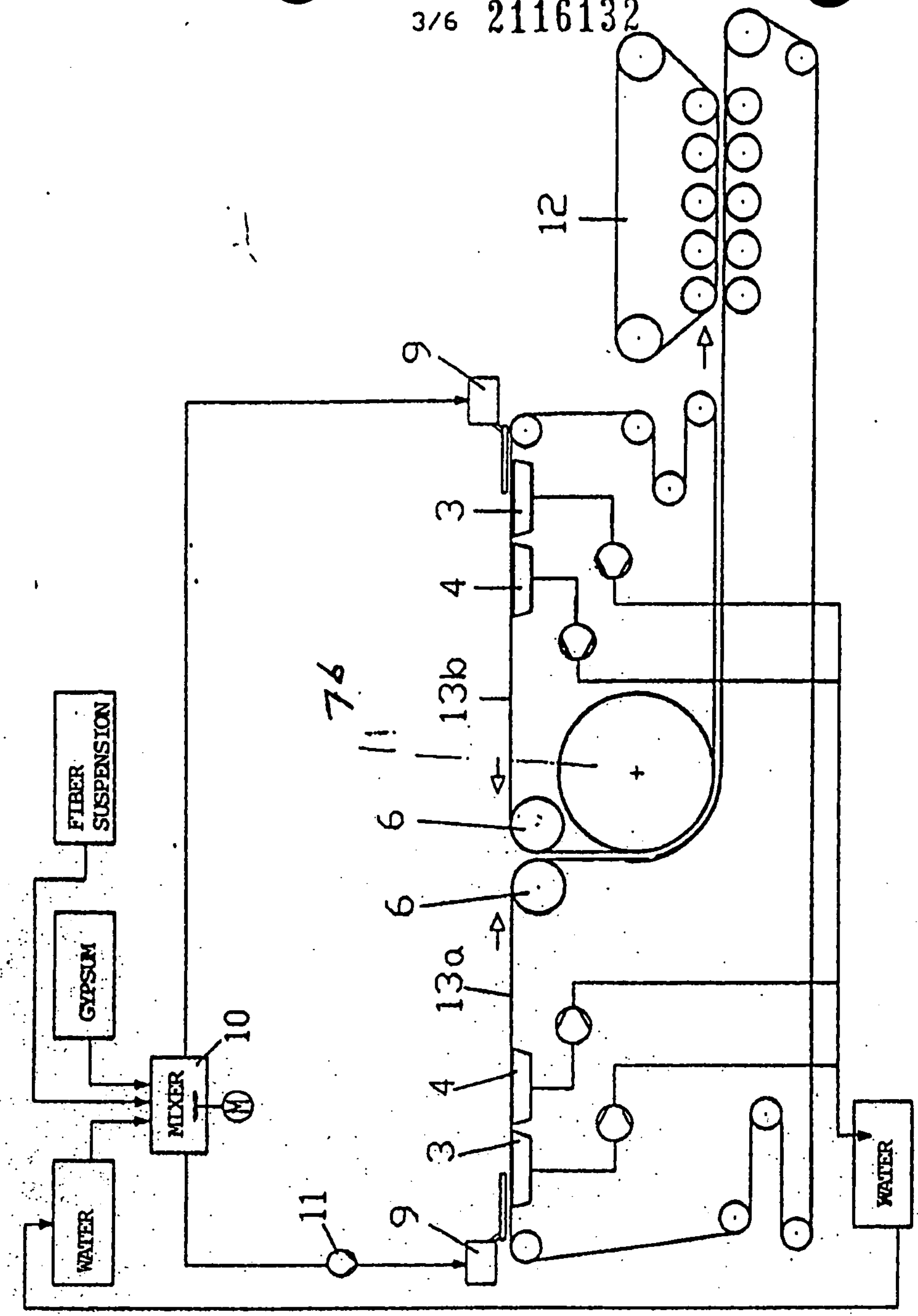

FIGURE3

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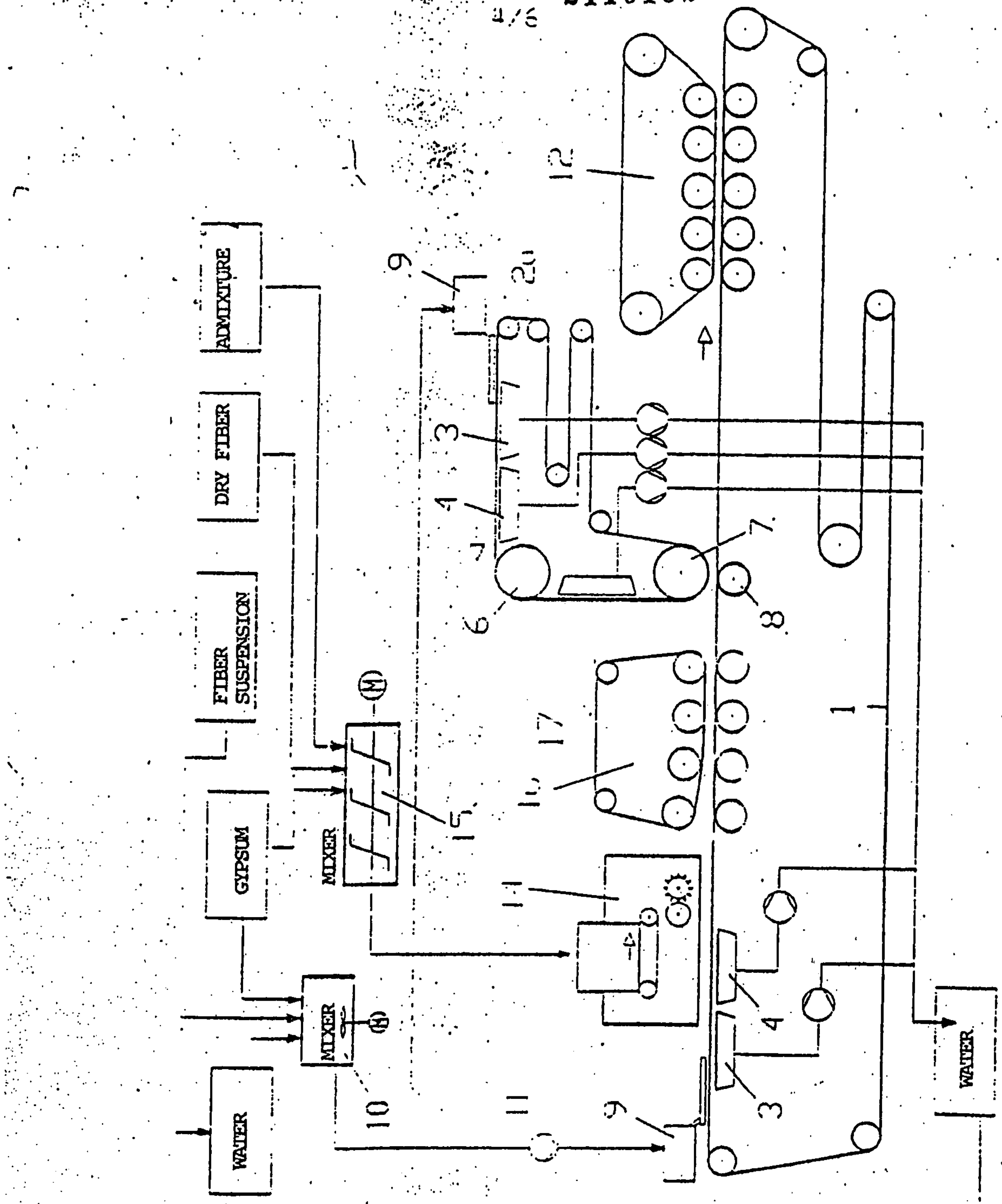

FIGURE 1

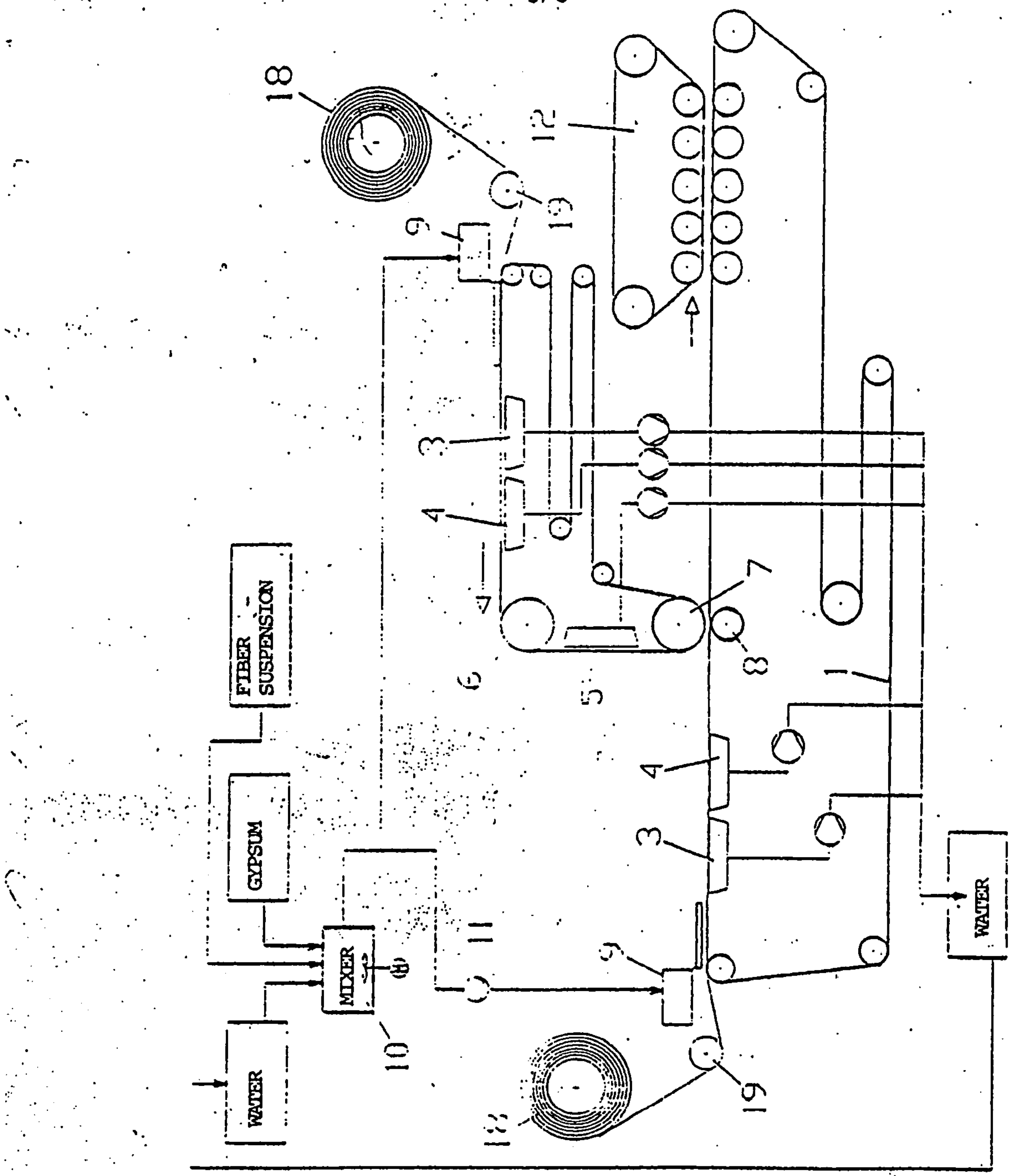
FIBER SUSPENSION
GYPSUM
MIXER
WATER
WATER
18
19
9
12
3
4
6
5
7
8
1
11
10

FIGURE 5

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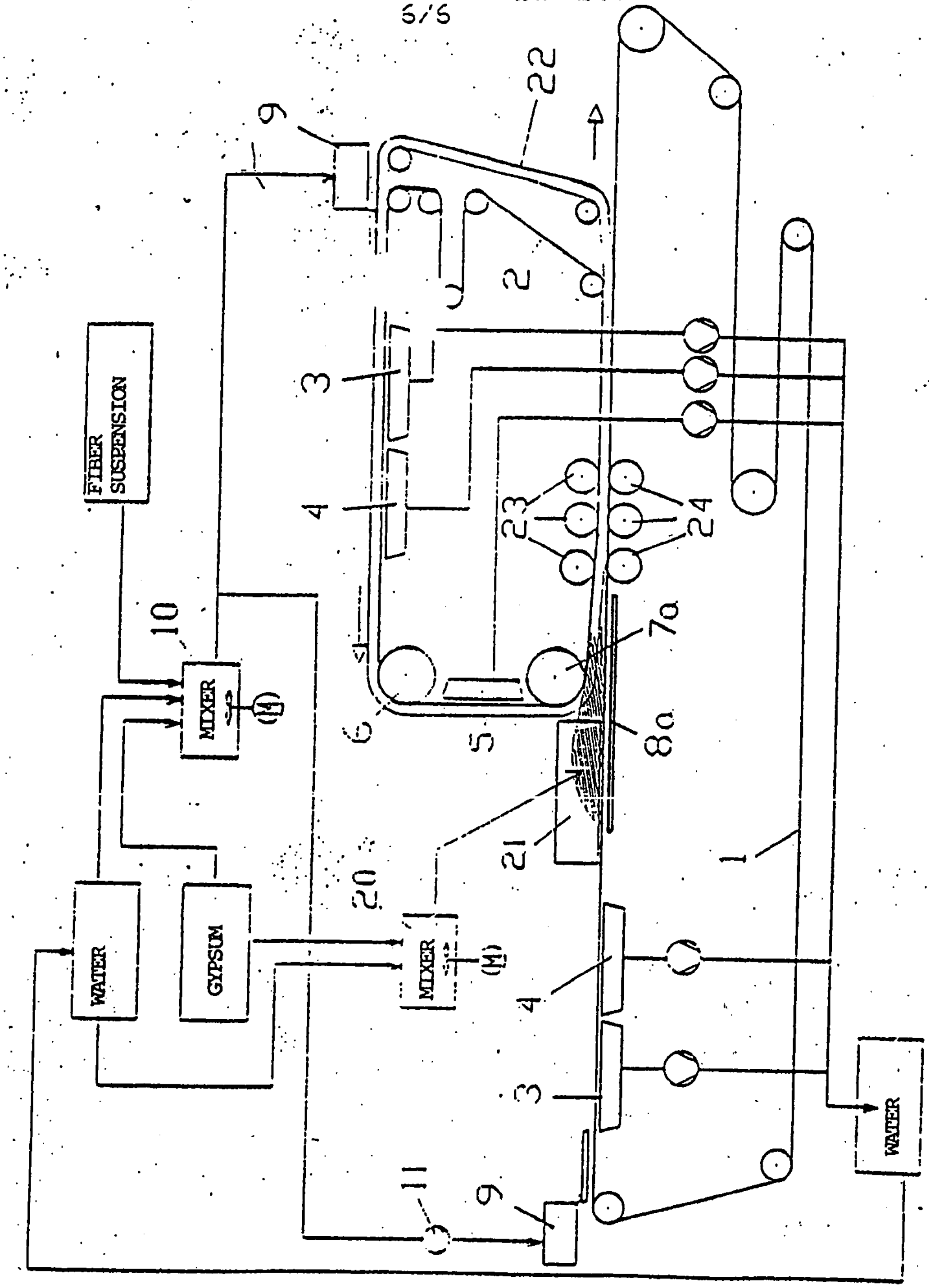

FIGURE 5